Maurice Colpron

CORDILLERAN WORKSHOP 1995, Ottawa-Carleton Geoscience Centre

Friday, February 10

7:00 p.m. Registration, social, and set-up of posters, Senate Room, 6th floor, Robertson Hall (Administration Building), Carleton University

Saturday, February 11
Morning Program - Cordilleran Miogeocline

8:00	Posters; coffee, juice and muffins
8:30	Introductory remarks
8:45	Marian Warren (Queen's) - An alternative interpretation of stratigraphic relationships between Neoproterozoic/Lower Cambrian rocks, southeastern Canadian Cordillera, and implications for continental rifting
9:00	Daniel Lebel (GSC, Calgary), Willem Langenberg (Alberta Geol. Surv.), and Eric W. Mountjoy (McGill) - Geometry and role of multiple thrust décollements, central Alberta Foothills
9:15	Tom Jerzykiewicz (GSC, Calgary) - New insights into Foothills stratigraphy and structure in southern Alberta
9:30	Kirk G. Osadetz (GSC, Calgary), Barry P. Kohn (La Trobe U., Australia), Shimon Feinstein (Ben Gurion U., Israel), and Raymond A. Price (Queen's) - Lewis thrust sheet thermal and geological history from fission-track data
9:45	Discussion
10:00	J. Murray Journeay and Stephen P. Williams (GSC, Vancouver) - GIS map library: a window on Cordilleran geology
10:15	Discussion, posters and coffee
11:15	Ian W.D. Dalziel (Texas at Austin) - Origin of the Cordilleran margin: testing SWEAT
11:30	Gerald M. Ross (GSC) and Nevine Boghossian, P. Jonathan Patchett, and George Gehrels (U. of Arizona) - Where did all that mud come from? Provenance evolution of the Cordilleran miogeocline from neodymium isotopic studies
11:45	Discussion
12:00	Lunch

Afternoon Program - Omineca Belt

1:00	Posters
2:00	James L. Crowley (Carleton) - Geochronological constraints on Early Proterozoic tectonism and Cordilleran overprinting in the Monashee complex, British Columbia
2:15	Dennis H. Johnston and Paul F. Williams (UNB, Fredericton) - Early Tertiary ductile extension along the west flank of the Thor Odin culmination of the Monashee complex, southeastern Canadian Cordillera, British Columbia

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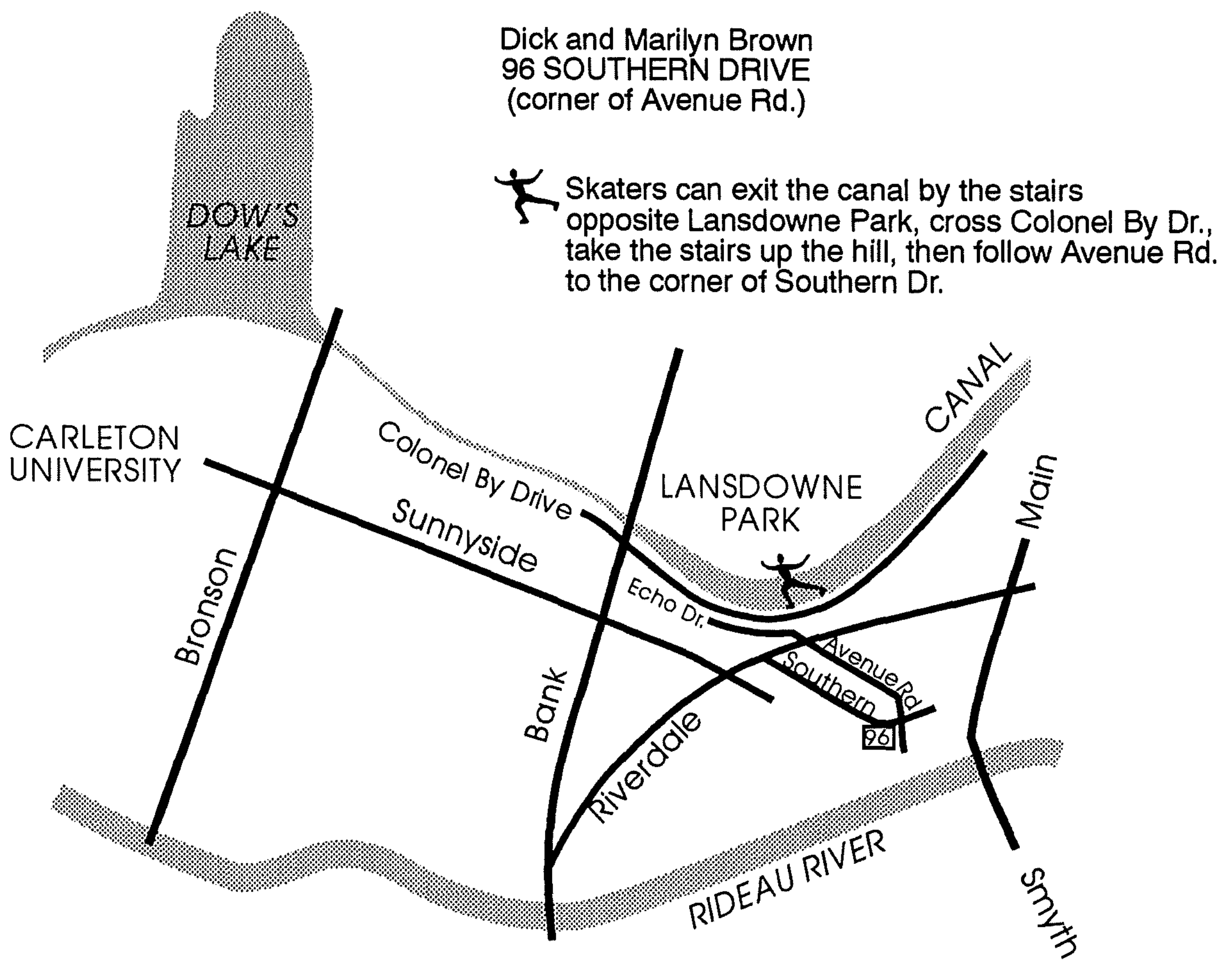
2:30	Bradford J. Johnson and Richard L. Brown (Carleton) - Crustal structure and early Tertiary tectonics of the Omineca belt at 51°N latitude, southern Canadian Cordillera
2:45	Discussion, posters and coffee
3:45	P. Simony (Calgary), E. Ghent (Calgary), S. Carr (Carleton), and S. Digel - Geometry of metamorphic isograds at the northern margin of Shuswap complex, northern Monashee Mountains, B.C.
4:00	Richard L. Brown (Carleton), Paul Williams (UNB), and Robert Scammell (GSC, Ottawa) - Crustal zones and progressive deformation, southern Canadian Cordillera
4:15	Discussion and posters
6:30	For those who have <u>prepaid</u>, dinner at the home of Dick Brown, 96 Southern Drive (730-6820) - see map below
8:30	<u>All</u> participants are invited to open house at 96 Southern Drive



Sunday, February 12
Program - Origin and accretion of terranes; *also* "neotectonic diversion"

8:30	Posters; coffee, juice and muffins
9:00	Heather E. Plint (Calgary) - Rock types, structure, and metamorphism in the Slide Mountain terrane and Finlayson Lake fault zone, Campbell Range, SE Yukon
9:15	JoAnne Nelson (BCGS) - Devonian galena-lead isotopic signatures of Yukon-Tanana and Stikinia: The North American connection
9:30	James K. Mortensen (UBC) - Westerly-derived Upper Triassic clastic sedimentary rocks in SE Yukon: Evidence for Early Mesozoic terrane interactions along the western margin of ancestral North America
9:45	Discussion
10:00	R.T. Patterson (Carleton) - Use of marsh foraminifera to recognize coseismic sea-level changes on Vancouver Island, British Columbia
10:15	Discussion, posters and coffee
11:15	Jochen Mezger (Alberta) - The Kluane Metamorphic Assemblage, SW Yukon - first steps towards developing a tectonic model
11:30	Douglas H. Oliver and Vicki L. Hansen (Southern Methodist) - Low-temperature prism <c> fabrics from quartz mylonites, Little Salmon Lake, Yukon Territory
11:45	Discussion
12:00	Lunch
1:00	Posters
1:30	Tekla A. Harms (Amherst) and Rob A. Stevens (Queen's) - Investigations in the Dorsey terrane: Lithologies and structure of (?)Paleozoic stratified rocks in the Stikine Ranges, northern British Columbia
1:45	Robert A. Stevens (Queen's) - Stratigraphy, structure and metamorphism in the Dorsey Range, southern Yukon Territory and northern British Columbia: The case for a separate and distinct Dorsey Terrane
2:00	Discussion
2:15	Fiona Childe (UBC) - U-Pb age constraints and Pb isotopic signature of the Kutcho Creek volcanogenic massive sulphide deposit: Implications for the terrane affiliation of the Kutcho Formation, north-central B.C.
2:30	J. Brian Mahoney (Wisconsin - Eau Claire) and Susan M. DeBari (San Jose State) - Early to Middle Jurassic volcanism in southern British Columbia: the relationship between the Bonanza and Harrison Lake arc systems
2:45	Discussion
3:00-4:00	Announcement of 1996 conference location followed by last poster session

Posters

Cordilleran Miogeocline

D.A. Archibald, D.K. Kisilevsky, and R.A. Price (Queen's)
$^{40}Ar/^{39}Ar$ study of K-feldspar from the Crowsnest Volcanics

Daniel Lebel (GSC, Calgary)
Geology map of the Waterton Lakes map area (NTS 82H/4)
southern Alberta NATMAP project

Ben Urlwin (Calgary)
The Yellowhead Platform (Miette Group): determination of its stratigraphic and geochemical significance to the Neoproterozoic

Omineca Belt

Maurice Colpron (Queen's) and Jim Logan (B.C. Geol. Surv.)
Recent developments in the geology of the Goldstream River area, northern Selkirk Mountains, B.C.

Mike Cooley (Queen's)
Structural and metamorphic evolution of the Quesnel Lake
Niagara Creek area, Cariboo Mountains, B.C.

James L. Crowley (Carleton)
Geochronological constraints on Early Proterozoic tectonism and Cordilleran overprinting in the Monashee complex, British Columbia

Dan H. Gibson (Carleton)
The Monashee décollement: structure, stratigraphy, and metamorphism of the northern Monashee complex, Hoskins Creek, British Columbia

J.L. Harvey (Carleton) and T.D. Hoisch (N. Arizona)
Thermobarometric constraints on exhumation of the Okanogan complex, Washington

Bradford J. Johnson and Richard L. Brown (Carleton)
Crustal structure and early Tertiary tectonics of the Omineca Belt at 51°N latitude, southern Canadian Cordillera

Larry S. Lane (GSC, Calgary)
Tectonic setting of Tertiary deformation, northern Yukon

Nathalie Marchildon and Gregory M. Dipple (UBC)
Distribution of metamorphic grades, Northern Selkirk Mountains, SE B.C.: poly-metamorphism and deformation

D.C. Murphy and D. Héon (Yukon Geoscience Office)
Geology and mineral occurrences of Seattle Creek map area (115P/16), western Selwyn Basin, Yukon

Leslie Reid and Philip Simony (Calgary) and Gerald M. Ross (GSC, Calgary)
The Isaac Lake synclinorium: the missing link in structural and stratigraphic evolution of the Cariboo Mountains, British Columbia

Gerald M. Ross (GSC, Calgary) and H. Roy Krouse (Calgary)
Sulfur isotopic composition of Windermere pyrites: significance for stratigraphic correlations, seawater chemistry and the evolution of metazoans

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Peter M. Schaubs and Sharon D. Carr (Carleton)
Stratigraphy of paragneisses in the Valhalla complex, southern Omineca Belt, British Columbia

Olivier Vanderhaeghe (Minnesota)
Structural analysis in migmatites of the Thor-Odin dome, Monashee complex, British Columbia

Marian Warren (Queen's)
New compilation map and accompanying structural, metamorphic, geochronological and stratigraphic data for central Purcell anticlinorium and Kootenay arc

Origin and Accretion of Terranes

P. Erdmer (Alberta) and E.D. Ghent (Calgary)
P-T-t evolution of high-pressure metamorphic rocks of the Yukon-Tanana Terrane: Tectonic implications

Carol Evenchick (GSC, Vancouver)
Depositional history of the northern two thirds of the Bowser basin and its implications for Jurassic western North American tectonics

General

J. Murray Journeay and Stephen P. Williams (GSC, Vancouver)
GIS map library: a window on Cordilleran geolog

John F. Psutka (B.C. Hydro)
Paleoseismic studies of the Bridge River area, southwestern British Columbia

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Abstracts for Talks and Posters (alphabetically by author)

$^{40}Ar/^{39}Ar$ study of K-feldspar from the Crowsnest Volcanics

Archibald, D.A., Kisilevsky, D.K., and Price, R.A.
Department of Geological Sciences, Queen's University, Kingston, Ontario K7L 3N6.

K-feldspar phenocrysts from alkalic dykes in the hangingwall and footwall of the Lewis thrust and from tuffs of the mid-Cretaceous Crowsnest Formation in the footwall of the Lewis thrust have been dated using conventional $^{40}Ar/^{39}Ar$ step-heating of bulk samples and $^{40}Ar/^{39}Ar$ laser probe fusion of individual grains. The three bulk samples yielded disturbed age spectra. Two hangingwall, bulk samples contain excess Ar and yield anomalously old dates. An argon isotope correlation plot for one of these suggests a cooling date of ca. 90 Ma. K-spar from the footwall bulk sample yielded an integrated date of 98.7±0.8 Ma (2σ) and a plateau segment date of 98.5±0.7 Ma; the Ar isotope correlation date was ca. 98 Ma. This spectrum suggests that the age of the rock is 98 Ma and that overprinting may have occurred in Paleocene time.

Selected K-feldspar grains from these and five other samples yielded single-grain, total-gas dates between 56 and 119 Ma. The youngest laser probe date is from a very altered, trachyte in the footwall of the fault. Generally, the laser-probe dates agree with the Ar isotope correlation dates for bulk samples. The fact that the single-grain dates cluster around 98 Ma suggests that (on a regional scale) the rocks were not heated above the Ar closure temperature of K-feldspar after mid-Cretaceous time.

U-Pb AGE CONSTRAINTS AND Pb ISOTOPIC SIGNATURE OF THE KUTCHO VMS DEPOSIT: IMPLICATIONS FOR THE TERRANE AFFILIATION OF THE KUTCHO FORMATION, NORTH CENTRAL BRITISH COLUMBIA

Childe, Fiona., Mineral Deposit Research Unit, The University of British Columbia, Vancouver, B.C., V6T 1Z4

The Kutcho volcanogenic massive sulphide deposit is hosted within the Kutcho Formation of the King Salmon Allochthon. The allochthon is composed of volcanic and intrusive rocks, conglomerate, limestone and argillite tectonically emplaced onto rocks of oceanic affinity of the Cache Creek terrane. The Kutcho Formation is the lowermost package of rocks within the King Salmon Allochthon and is composed predominantly of bimodal volcanic rocks. The volcanic rocks contain minor amounts of intercalated fine-grained sediments and are cross-cut by at least two types of felsic intrusives.

The Kutcho deposit has reserves of 17 Mt of 1.6% Cu, 2.3% Zn, 29 g/t Ag and 0.3 g/t Au (B.C. MINFILE). Although usually classified as a Kuroko-type deposit due to the association of massive sulphide mineralization with fragmental felsic volcanic rocks, the deposit is lacking many of the common characteristics of a Kuroko-type deposit. The deposit is characterized by a very low lead concentration, lack of sulphate (±Ba) facies and significant dolomite, in addition to the typical sericite alteration in both the footwall and hangingwall alteration zones.

U-Pb zircon dating of a quartz-phyric rhyolite which forms the immediate hangingwall to mineralization and a quartz-plagioclase porphyritic intrusive of rhyolitic composition within the footwall of the deposit has yielded preliminary Permo-Triassic ages of 249±7 Ma and 249±13 Ma, respectively. Pb isotopic compositions of bornite, chalcopyrite and pyrite from the main ore lenses are: $^{206}Pb/^{204}Pb$ = 18.43-18.51, $^{207}Pb/^{204}Pb$ = 15.51-15.61, $^{208}Pb/^{204}Pb$ = 37.87-38.04. These values are markedly less radiogenic than lead signatures of Devono-Mississippian to Jurassic VMS deposits within the island arc assemblages of Stikinia, Wrangellia and Alexander terrane. The Stikine terrane, which presently lies to the west and south of the King Salmon Assemblage contains volcanic rocks of Permian age. However, the lead isotopic data from this study suggest that the massive sulphide-bearing Kutcho Formation formed in a more primitive tectonic setting than Stikinia, perhaps within a volcanic arc of unusual character constructed on the oceanic Cache Creek or Slide Mountain terranes.

RECENT DEVELOPMENTS IN THE GEOLOGY OF THE GOLDSTREAM RIVER AREA, NORTHERN SELKIRK MOUNTAINS, B.C.

Colpron, Maurice, Queen's University, and Logan, Jim, B.C. Geological Survey Branch

Recent mapping in the Goldstream River area shows the area to be underlain by two stratigraphic and structural domains bounded by the SW-verging French Creek fault. East of the fault, strata of the Horsethief Creek and Hamill groups are deformed by N-trending, W-verging recumbent folds. To the west, the core of the NW-trending, SW-verging Goldstream anticline is occupied by white marble correlated with the Badshot Formation. The Badshot is overlain (with apparent conformity) by a sequence of black phyllite, green phyllite and chlorite schist, and quartzite and grits similar to the Lardeau Group stratigraphy observed in the Illecillewaet synclinorium to the southeast. These stratigraphic correlations imply that SW-verging folds west of the the French Creek fault deform an upright panel of Lower Paleozoic rocks. The French Creek fault is a probable northern extension of the Downie Creek fault, which dies out in the core of the Illecillewaet synclinorium some 50 km to the southeast.

The area is intruded by four granitic plutons. The Goldstream pluton has previously been interpreted as a prekinematic pluton of possible Paleozoic age. Our mapping shows the pluton to clearly postdate all compressional structures in the area. $^{40}Ar/^{39}Ar$ geochronometry from hornblende of Goldstream pluton yield a plateau age of 114±5 Ma that confirms field observations. Other plutons of probable Cretaceous age include the Long Creek and Downie Creek stocks. The latter is a two-micas leucogranite similar to Late Cretaceous intrusives on Mount Revelstoke.

In the northeastern part of the map-area, the NNW-trending, syn- to post-kinematic Windy Range metamorphic culmination is highly discordant with the regional structures. Andalusite pseudomorphs after kyanite along its southern flank indicates that the culmination records an episode of decompression (from bathozone 5+ to bathozone 3-4) during, or shortly after regional deformation. Similar observations in the aureole of Adamant pluton suggests that the pluton is genetically linked with the Windy Range culmination. This interpretation implies that the 169 Ma zircon age from Adamant pluton may date its emplacement as well as the metamorphism.

GEOCHRONOLOGICAL CONSTRAINTS ON EARLY PROTEROZOIC TECTONISM AND CORDILLERAN OVERPRINTING IN THE MONASHEE COMPLEX, BRITISH COLUMBIA

Crowley, James L., Department of Earth Sciences and Ottawa-Carleton Geoscience Centre, Carleton University, Ottawa, Ontario, K1S 5B6

The Monashee complex in the hinterland of the southern Canadian Cordillera exposes the oldest known rocks and deepest structural level in the Cordillera. The complex is a tectonic window beneath the Monashee decollement, a crustal-scale thrust fault that is interpreted as correlating with the sole thrust of the Rocky Mountain Foreland belt. Field relationships and U-Pb data from core gneisses of Frenchman Cap dome, a culmination in the northern part of the complex, indicate that there are zones in which the Cordilleran overprint was not complete, thus allowing for at least partial deduction of the early tectonic history. Outcrop- to km-scale zones of incomplete Cordilleran transposition deformation are delineated by ubiquitous ~1.91 Ga granitic dykes which postdate a migmatized gneissic fabric and are variably affected by the superposed Cordilleran deformation. Uncertainty on this and other Early Proterozoic U-Pb zircon ages is attributed to moderate Pb-loss during Cordilleran reheating that was superimposed on differing amounts of inheritance in these crustal melts. In the deepest structural level yet mapped, the undeformed nature of a 1.85 Ga pegmatite dyke, along with weak Cordilleran fabric in nearby ~1.91 Ga granitic and ~1.84 Ga pegmatite dykes, require that at this level the early fabrics were only mildly affected by the Cordilleran overprint. Strong Cordilleran fabric in the 1.86 Ga granodioritic gneiss at the highest level exposure of Early Proterozoic rocks requires that this level was thoroughly affected by the overprint. The Early Proterozoic deformation is constrained to be older than the ~1.91 Ga granitic dykes and younger than 2.08 Ga augen gneiss that contains the early fabrics. The timing of metamorphism is approximated by monazites in pelitic schist from deep levels which yield ~2.06 Ga upper intercept U-Pb ages. These monazites and others in Early Proterozoic intrusions indicate that Cordilleran metamorphism was not hot or prolonged enough at this level to reset the U-Pb system. Another population of monazites in schists yield concordant 50-52 Ma U-Pb dates that are interpreted as the time of peak Cordilleran temperature at this level.

These U-Pb data together with fabric observations require that dramatic Cordilleran strain gradients occur in the Monashee complex. The structurally deep Early Proterozoic gneisses are in part only weakly disturbed by the Cordilleran deformation whereas fabrics and young intrusives in overlying rocks have been completely transposed.

Origin of the Cordilleran margin: testing SWEAT

Dalziel, Ian W.D., Institute for Geophysics, University of Texas at Austin, 8701 Mopac Boulevard, Austin, TX 78759

A new scenario for global Neoproterozoic/Early Paleozoic paleogeography emerged with the suggestions by Moores (1991) and Dalziel (1991) that the Pacific margins of the North American and East Antarctic-Australian cratons were juxtaposed in the Late Precambrian and formed as a conjugate rift pair. This reconstruction implies that the Grenville Front continues into Antarctica near the eastern shore of the Weddell Sea, separating isolated basement exposures in Coats Land from 1.6 to 1.8 Ga basement of the Shackelton Range. The nunataks in Coats Land have yielded "Grenvillian" ages (1 Ga). These nunataks are the most critical outcrops for testing the validity of the Southwestern United States-East Antarctica (SWEAT) connection.

The Bertrab Nunataks are three isolated exposures of granophyre. We collected 10 oriented samples at each of four sites in the granite and at one site in a rhyolite dike. Approximately 10 km to the east are the four nunataks of the Littlewood group. All are composed of porphyritic rhyolite and represent ash flow tuffs. At each of three sites in one of the nunataks we collected 10 samples.

The hematite-bearing Littlewood samples carry a very well defined single component magnetization, and the magnetite-bearing Bertrab samples have a low blocking temperature modern overprint as well as a high blocking temperature component. The stable site mean directions are statistically indistinguishable and yield a mean pole position at 23.9°S, 258.5°E with a95 = 4.0°.

Juxtaposing East Antarctica with the Pacific margin of cratonic North America, as suggested by the SWEAT hypothesis, places the pole position from Coats Land directly on the Grenville apparent polar wander path, giving strong support to the proposed plate reconstruction.

The talk will explore implications of the new data for timing and geometry of break-up and opening of the Pacific Ocean basin.

P-T-t EVOLUTION OF HIGH-PRESSURE METAMORPHIC ROCKS OF THE YUKON-TANANA TERRANE: TECTONIC IMPLICATIONS

Erdmer, P., Department of Geology, University of Alberta, Edmonton, AB, T6G 2E3, Ghent, E.D., Department of Geology and Geophysics, University of Calgary, Calgary, AB, T2N 1N4.

It is clear from recent advances in the tectonics of the northern Canadian Cordillera, and in particular from the emerging record preserved in accreted arc and oceanic terranes fringing ancient North America, that the effects of Late Paleozoic subduction were far-reaching. One of the few unquestioned elements in different current hypotheses of terrane evolution is the central nature of the Permo-Triassic blueschist and eclogite belt that stretches from Yukon to Alaska and that is interpreted to derive from late Paleozoic subduction. We are studying the P-T-t histories of the high-pressure rocks to determine whether all high-pressure mineral assemblages record the same history, and whether the metamorphism is of a single age. The collision-derived allochthonous host rocks of the high-pressure assemblages underwent intense ductile strain; how much of this strain results from subduction-zone processes, and how much from collision and nappe emplacement is a subject of current debate. Continuing regional study of the host rocks will contribute to answering this question, but the high-pressure rocks themselves exhibit high-grade mylonitic fabrics and thus offer a unique chance to solve the problem.

DEPOSITIONAL HISTORY OF THE NORTHERN TWO-THIRDS OF THE BOWSER BASIN AND ITS IMPLICATIONS FOR JURASSIC WESTERN NORTH AMERICAN TECTONICS

Evenchick, Carol A., Geological Survey of Canada, 100 West Pender St.,Vancouver, BC V6B 1R8.

The Bowser basin is a Middle Jurassic to mid-Cretaceous marine and nonmarine basin which formed on an allochthonous terrane, Stikinia, during and after its amalgamation to the western margin of North America. Its deposition, beginning in Aalenian time, records a fundamental change of Stikinia from island arc to vast marine depocenter whose source was largely the Cache Creek terrane to the east. Westward obduction of Cache Creek resulted in final closure of the ocean between Stikinia and North America. Middle Jurassic (Bajocian, Bathonian, and Callovian) deposition was mainly marine and restricted to the north and northeast. In Late Jurassic (mid-Oxfordian to Kimmeridgian) time, shallow marine and deltaic facies prograded westward over the more distal facies, and were bounded on the west by a large region of submarine fan deposition. In latest Jurassic or earliest Cretaceous time the western basin was still relatively deep marine. Mid-Cretaceous alluvial and fluvial deposits are present in the north-central basin.

Depositional facies patterns, paleocurrents, and clast types indicate that the northern two-thirds of the Bowser basin was derived from the north and northeast and filled progressively westward in an overall regressive succession. There is no widespread record of volcanogenic detritus following the demise of the Stikinian arc in Bajocian time, and there is no record of a volcanic arc or any other source west of Stikinia from late Middle Jurassic through earliest Cretaceous time. Strata of the Bowser basin bear no lithologic resemblance to partly coeval rocks of the Gravina basin farther west. Models of amalgamation of Alexander and Wrangellia terranes to Stikinia in late Middle Jurassic, Late Jurassic, or earliest Cretaceous time which require the Bowser basin to be marginal to a volcanic arc are not supported by the depositional record of the basin.

The Bowser basin cannot be attributed to any one tectonic process. Major controls on Jurassic deposition were probably flexural subsidence resulting from the westward obduction of Cache Creek onto Stikinia and thermal subsidence following long-lived magmatism on Stikinia which ceased in earliest Bowser history. Their relative significance in space and time throughout Jurassic deposition is unknown. The Bowser basin was neither a forearc or backarc basin from late Middle Jurassic time onward. Mid-Cretaceous fluvial and alluvial fan deposits are inferred to have been deposited in a piggy-back basin in the mainly Cretaceous Skeena Fold Belt at the same time as fluvial sediments were deposited east of the fold belt in the mid- to Late Cretaceous Sustut Basin.

THE MONASHEE DECOLLEMENT: STRUCTURE, STRATIGRAPHY, AND METAMORPHISM OF THE NORTHERN MONASHEE COMPLEX, HOSKINS CREEK, BRITISH COLUMBIA

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The Monashee complex is a domal shaped culmination found in the southern Omineca belt of the Canadian Cordillera. The complex is further subdivided into the Frenchman Cap dome in the north and Thor-Odin dome to the south, both cored by Early Proterozoic orthogneisses and older paragneisses, which are thought to be exposures of the North American Craton. These rocks have been interpreted to lie in the footwall of a northeasterly directed thrust fault known as the Monashee decollement. The hanging wall of the decollement consists of deformed and metamorphosed North American continental margin and oceanic accreted terranes of the Selkirk allochthon, which is considered to have a minimum displacement of 80 km.

Field relations, kinematics and geochronology indicate that the shear zone has experienced a complex history. The decollement zone, documented as bounding the western margin of the Monashee complex, is well exposed in the northern section of the Frenchman Cap dome and has been studied by previous workers in varying amounts of detail. The objective of this new inquiry is to examine this area in greater detail and build on the available data base to further test the interpretation. A structural, stratigraphic, and metamorphic investigation at a scale of 1:10 000 was initiated in 1994 and will be continued in the 1995 field season.

Investigations in the Dorsey terrane: Lithologies and structure of (?)Paleozoic stratified rocks in the Stikine Ranges, northern British Columbia

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Although presently divided between Slide Mountain and Dorsey terranes, (?)Paleozoic strata across the Stikine Ranges of northern British Columbia have demonstrable lithologic similarities. Areas of the Stikine Ranges studied during the 1994 field season are dominated by clean quartz sandstone, fossiliferous and unfossiliferous limestone, and shale, which occur in laterally continuous, lithologically distinctive and homogeneous, mappable units. The character of this suite of rocks suggests a continental margin origin for the sequence, despite the presence of volcanic rocks in the domain assigned to the Slide Mountain terrane. These strata are deformed by both map scale and outcrop scale, tight to isoclinal, reclined to recumbent, similar folds that appear to be south-vergent. Full description of the stratigraphy and geologic history of the Stikine Ranges and Dorsey terrane will require further detailed mapping of the units and structures of the area.

THERMOBAROMETRIC CONSTRAINTS ON THE EXHUMATION OF THE OKANOGAN COMPLEX, WASHINGTON.

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The Tunk Creek amphibolite (TCA) of the Okanogan Complex, Washington, contains granulite facies sapphirine-spinel-corundum parageneses. The TCA outcrops near the Okanogan valley fault (OVF) at Keystone, Washington, in one of the structurally lowest exposures in the region, underlying both the OVF mylonites and the Tonasket Gneiss. Fabrics in the TCA parallel those of the overlying Tonasket Gneiss and the OVF mylonites, suggesting that most fabrics formed during the early Tertiary extensional deformation. However, reliable shear sense indicators are uncommon in the TCA, and some relationships suggest a partially preserved earlier deformation.

Peak P-T conditions from the TCA are estimated at 820°C, 10.2 kb, using sapphirine-spinel thermometry and the reaction 2Co + Di = Sp + An, with thermodynamic data of Berman (1991). Garnet amphibolites from the overlying Tonasket Gneiss yield similar temperatures (820-840°C) using the revised plagioclase-hornblende thermometer, but yield discrepant garnet-hornblende pressures of 6.5 kb. These data suggest an isothermal decompression path for the TCA, consistent with exhumation during extension.

The P-T and structural data permit the conclusion that Eocene extension exhumed rocks from depths of over 30 km, consistent with large magnitudes of extension previously reported for the Okanogan fault. However, some late Cretaceous uplift may have occurred as well. Thus, these data establish the maximum amount of vertical displacement resulting from Eocene extension.

NEW INSIGHTS INTO FOOTHILLS STRATIGRAPHY AND STRUCTURE IN SOUTHERN ALBERTA

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The refinement of stratigraphy of the Belly River and contiguous rocks in the Cordilleran thrust and fold belt helps in (1) the recognition, definition and mapping of some poorly understood or otherwise overlooked structure (e.g. the imbricate stack in footwall of the Livingstone Thrust); (2) the correct placement of the UZA-3/UZA-4 sequence boundary in the Foothills at the base of the Connelly Creek Formation; (3) reinterpreting the succession of sedimentary environments that developed during and after the Colorado Sea regression from the Crowsnest Embayment as a response to the orogenic activity in the Cordillera.

CRUSTAL STRUCTURE AND EARLY TERTIARY TECTONICS OF THE OMINECA BELT AT 51°N LATITUDE, SOUTHERN CANADIAN CORDILLERA

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A crustal cross section through the Omineca belt at the latitude of the Trans-Canada Highway is presented. The section has been drawn to satisfy available surface geological information and seismic data recently acquired from Lithoprobe transects of this part of the Cordilleran hinterland. Palinspastic restoration of Tertiary normal sense shear zones leads to the conclusion that the Omineca belt at latitude 51°N was extended in the Eocene by 20-25%. It is shown that the Okanagan - Eagle River fault, bounding the western margin of the Shuswap complex, may have accommodated approximately 30 km of displacement. Restoration of this fault together with 15 km of restored displacement on the eastern flanking Columbia River fault juxtaposes upper crustal rocks with compatible stratigraphic, structural and metamorphic histories. The restoration indicates that the continental crust was approximately 50 km thick prior to Eocene extension. Comparison of the crustal geometry in the present and restored sections suggests that extensional strain was likely to have been partitioned such that the upper crust was most highly attenuated above the central Shuswap complex, whereas the lower crust was most greatly stretched beneath the Intermontane and western Omineca belts.

EARLY TERTIARY DUCTILE EXTENSION ALONG THE WEST FLANK OF THE THOR ODIN CULMINATION OF THE MONASHEE COMPLEX, SOUTHEASTERN CANADIAN CORDILLERA, BRITISH COLUMBIA.

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The northern Frenchmans Cap and southern Thor Odin culminations of the Monashee Complex are comprised of Early Proterozoic basement "core" gneiss unconformably overlain by Middle Proterozoic to early Cambrian platformal "cover" metasediments. The Monashee Complex has been interpreted as a tectonic window exposed through the Selkirk Allochthon, separated from the allochthonous rocks by an east-directed thrust fault - the Monashee Décollement (MD).

On the west flank of Thor Odin, we do not see a clear structural break in an indeterminate zone between cover gneiss at Davis Peak and parautochthonous platformal metasedimentary rocks at Joss Mountain. At Joss Mountain, the structurally highest units are an overturned marble and quartzite, correlated with early Cambrian Hamill Group quartzite and overlying Badshot Formation marble.

Where the MD is presently mapped, we see an approximately 1 km thick, west dipping zone where top-to-the-west shear bands are concentrated. The shear bands occur on a 1 to 5 m scale - rare shear bands are in excess of 100m. The shear bands are coeval with a suite of 52 Ma tourmaline-bearing pegmatite dykes which generally overlap in time with lamprophyre dykes. These dykes cut three generations of folds. F_1 cm to km scale isoclinal folds are overprinted by tight asymmetric SW-NE trending F_2 folds, producing a S_2 transposition foliation. More open F_3 folds are N- to NE-verging along the west flank of the culmination, SW-verging west of the culmination at Joss Mountain. N-S oriented boudins and neck folds, associated with F_1/F_2 and the late shear bands, indicate E-W horizontal extension. 52Ma tourmaline-bearing pegmatite fills a post-F_3 E-W extensional pull-apart within an F_1/F_2 kilometre-scale boudin.

The west dipping zone of concentrated shear bands is evidence that extension occurred as a result of slip on reactivated S_2 surfaces. Rare F_3 folds are truncated by slip on S_2. A post-F_3 W-SW sillimanite lineation is a record of this slip- offsets of pegmatite and lamprophyre dykes across shear bands are consistent with movement parallel to this prominent lineation. Slip on reactivated S_2 surfaces allows for significant extension in addition to that along east- and west-dipping normal faults for rapid unroofing and cooling of the Monashee Complex in the early Tertiary.

GIS MAP LIBRARY: A WINDOW ON CORDILLERAN GEOLOGY

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Much like a conventional library that organizes information by volume, subject and index number, a GIS map library is a self-sustaining organizational system for archiving, analyzing and updating large volumes of digital map and related database information. It partitions data by tile and by layer; each is linked to associated databases of information by means of a digital indexing system. It is designed to maintain internal consistency and data standards as an archival facility, and to provide efficient and seamless access to large and complex data sets for purposes of data integration, analytical research and/or cartographic production.

The GIS Map Library of the Canadian Cordillera (GSC Open File 2948) contains a folio of 22 NTS map tiles (1:1,000,000 scale), each comprising separate thematic layers of geologic and geographic information derived from the Tectonic Assemblage Map of the Canadian Cordillera (Wheeler and McFeely, 1991; GSC Map 1712A). Each of these layers is linked to associated geologic and geographic databases that maintain information on tectonic assemblage, terrane affinity, rock type, geologic age, stream type, road classification, source of data, etc. These linkages support complex spatial queries and provide the necessary infrastructure for analyzing and integrating digital data sets for the Canadian Cordillera.

The GIS Map Library is designed to run with most commercial GIS packages that support the ARC LIBRARIAN data model. The data are also formatted for use as individual map tiles on DOS and WINDOWS platforms, and are portable to a variety of GIS, CAD and Desktop Publishing applications that accept standard .e00, ,dxf, ungen, .ai, dbf and ASCII file formats.

TECTONIC SETTING OF TERTIARY DEFORMATION, NORTHERN YUKON

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Northern Yukon contains four distinct mountain ranges (British, Richardson, Dave Lord-Keele, and Ogilvie). Together with the offshore Beaufort Foldbelt and the northeastern Brooks Range of Alaska, they contain a complex array of folds and thrust faults of Laramide (early Tertiary) age. Superimposed on those structures are locally identified structures of Miocene to Recent age.

Although the region is more than 500 km from the nearest plate margin, the deformation can be linked to interactions among North America, Eurasia, and oceanic plates of the paleo-Pacific margin during latest Cretaceous and Tertiary time. In contrast to the southern Cordillera, Laramide deformation in the northern Yukon was produced predominantly by east-west compression between North America and Eurasia. That compression was transmitted eastward by translation of Arctic Alaska along the Kaltag and Kobuk faults, and was accommodated by east-west shortening of eastern Alaska and northern Yukon against the North American craton.

Complex structural trends reflect the interplay of tectonic stresses, pre-existing structural trends, and boundary conditions due to regional variations in crustal architecture. Major crustal elements controlling deformation geometry and style include the Beaufort-Mackenzie Basin margin, Richardson Trough, Blow Trough-Kandik Basin, and Yukon Stable Block. Arcuate structures in the offshore Beaufort Foldbelt resulted from lateral escape northward across the continental shelf. Competent Paleozoic shelf carbonates of the Yukon Stable Block (a rifted block of North American craton) resisted deformation. At the borders of the block, incompetent shale troughs, as well as their thinned basements, localized shortening and were tectonically inverted. The nearly rectilinear form of the Richardson, Ogilvie and Dave Lord-Keele ranges around the less-deformed Yukon Stable Block reflect those competence contrasts.

Northward-directed Miocene and younger deformation is detected only in the northeastern Brooks Range and offshore Beaufort Foldbelt. It appears to result from compressive stress, generated by Pacific-North America convergence, and transmitted across the width of the Cordillera to the Beaufort Sea region.

Geometry and role of multiple thrust décollements, central Alberta Foothills

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Regional mapping, the study of data from deep petroleum exploration wells and the construction of a series of cross-sections through the Athabasca-Brazeau portion of the central Canadian Rocky Mountain thrust-fold belt outline three types of first order décollement within or along the border of the present orogenic wedge: basal décollement, intermediate or *internal* décollement and an upper décollement. The evolution of these different structural elements appear to have been intimately interrelated and influenced by the overall geometry of the orogenic wedge. The presence of a prominent upper décollement and low-taper triangle zone is better defined.

The basal décollement changes stratigraphic position both laterally and toward the foreland and has two ramps: one from the base of the stratigraphic pile to a slippage zone in the Devonian and another from this flat to another flat in the Upper Cretaceous. This last flat corresponds to the upper décollement above which a southwest-verging panel overrides the foreland portion of the orogenic wedge. Internal décollements are recognized by layer-parallel glide horizons that correspond to extensive flat segments above a ramp. These ramps link each internal décollement to the basal décollement situated in the more hinterland area of the orogenic wedge. Basal and internal décollements are similar in geometry in that several imbricate fault systems emanate from each. In the study area, six extensive layer-parallel glide horizons are recognized: the Banff and basal Palliser formations (basal décollement); the Fernie Group, the upper portion of the Nikanassin Formation, and the Blackstone Formation (internal décollements) and the Wapiabi Formation (upper décollement). Successive forward shifts of the basal décollement to deeper horizons within the stratigraphic pile led to the formation of internal décollements. These internal décollements are in some cases cross-cut by younger faults rising from deeper and more northeastward décollements.

NE-verging and SW-dipping faults that cut through the Brazeau and Paskapoo Formations, are present at the surface northeast of the Brazeau thrust. These faults indicate that part of the upper décollement was carried by younger, deeper thrusts during the late stages of deformation. Seismic data recently accessed through Husky Oil and Mobil Oil suggest that the upper décollement panel is substantially larger that previously described in cross-section. A new cross-section shows little or no shortening within the Upper Cretaceous and Tertiary stratigraphic pile. The presence of several internal décollements in the study area also signifies that conventional section balancing using relative bed lengths must be done for the entire Foothills to produce valid cross-sections and must take into consideration possibly large discrepancies between shortening values observed above and below the upper décollement.

Geology map of the Waterton Lakes map area (NTS 82H/4)-Southern Alberta NATMAP project

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Bedrock mapping of the Waterton Lakes area was conducted as part of the second year of research associated with the Southern Alberta Foothills NATMAP project. This five-year project (1993-1998) will produce a new digital geoscience database for the eastern edge of the Cordillera in southern Alberta, comprising new bedrock geological maps such as the one presented here and new cross-sections of subsurface structure established in cooperation with the petroleum industry using proprietary seismic information.

The Waterton Lakes map area overlaps the southern Alberta Foothills and the Rocky Mountain Front Ranges geological divisions and lies immediately north of the Canada-U.S.A. border. The western part of the area is marked by the Lewis thrust sheet (Mesoproterozoic Purcell Supergroup) and the Foothills belt in the eastern part (only Upper Cretaceous strata are exposed at the surface). Field work during the 1993 and 1994 field seasons focussed on the remapping of the Mesozoic strata found in the Foothills to apply the new stratigraphic units within the Alberta and Belly River groups recognized recently for the Crowsnest Pass area.

Structure of the outer Foothills is largely inferred from two relatively well exposed outcrop sections across the structure. The Foothills of the eastern part of the Waterton Lakes area consist of a series of closely spaced southwest-dipping, northeast-verging thrust faults deforming Upper Cretaceous strata with no intervening southwest-directed, northeast dipping thrust fault (backthrust). However some northeast-directed, northeast-dipping folded thrust faults were observed locally and are interpreted to extend over a wide area in the interior part of the Foothills of the area. Interpretation of air photographs, and reevaluation of the structure of several critical sections allows to outline a few, broadly folded thrust sheets composing the overall surface structure of the area. Beneath these thrust sheets, the Wapiabi Formation is more deformed locally and generally by extension. In the interior Foothills of the area strata and faults display generally low attitudes and are involved in broad folds. Along the escarpments situated on both sides of the valley of the head of the Belly River, strata are nearly flat lying, cut by no significant thrust fault. In contrast, in exposures along the North Belly River (west branch of the headwaters of the Belly River), the stratigraphically underlying Wapiabi Formation stata are significantly more folded and faulted, cut and duplicated by a series of moderately to steeply inclined, south-west dipping thrust faults. To explain the discrepancy in shortening observed between these two stratigraphic units, a décollement horizon is interpreted near the top of the Wapiabi Formation.

DISTRIBUTION OF METAMORPHIC GRADES, NORTHERN SELKIRK MOUNTAINS, SE B.C.: POLY-METAMORPHISM AND DEFORMATION

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The complex distribution of metamorphic assemblages in pelitic rocks of the Northern Selkirk Mountains north of Goldstream River and west of French Creek is the result of 1) a polyphase metamorphic evolution; and 2) a protracted history of deformation including possible late- to post-metamorphic faulting. Evidence exists for at least two, possibly three, distinct thermal pulses having affected rocks of the area. Porphyroblasts pseudomorphed by retrograde minerals contemporaneous with the development of the main regional foliation (S_n) indicate that an early metamorphic pulse pre-dated, or took place early in the development of this foliation. This was followed by cooling which produced the retrograde minerals. A later prograde metamorphic pulse is characterized by the late- to post-S_n development of a Barrovian sequence of metamorphic zones. Biotite, chlorite and muscovite aligned along a late (S_{n+1}) crenulation cleavage may represent a third metamorphic pulse, though preliminary petrographic observations do not reveal intervening retrogression of the Barrovian assemblages, and could be consistent with a single protracted, late-S_n to early-S_{n+1} metamorphic pulse. In addition to a complex thermal evolution, their is some evidence in support of late- to post-metamorphic low angle faulting. Where observed, the staurolite isograd associated with the Barrovian metamorphism coincides with the occurrence of a strongly strained layer of metamorphosed psammitic rock (L-tectonite). The first occurrence of staurolite-bearing assemblages may therefore reflect a late structural break rather than a smooth thermal gradient. Other field evidence also suggests local, late- to post-metamorphic deformation. Cretaceous-age, low-angle faulting occurs in nearby areas (Monashee décollement to the west, across the Columbia River) and if real, the inferred shear zone may be related to this, or to later Eocene extensional faulting along the Columbia River Fault. Ongoing work will attempt to clarify the tectono-thermal evolution of this area and clarify the effects of fluid flow during prograde and retrograde metamorphic episodes.

Early to Middle Jurassic volcanism in southern British Columbia: the relationship between the Bonanza and Harrison Lake arc systems

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Early to Middle Jurassic volcanic rocks are exposed throughout the southern end of the Coast Plutonic Complex, and include the Bonanza Group, Bowen Island Group, and Harrison Lake Formation. The Bonanza Group and Bowen Island Group are assigned to Wrangellia; the Harrison Lake Formation is part of the Harrison terrane. Early to Middle Jurassic strata on these terranes comprise volcanic arc assemblages containing a diverse suite of basaltic to rhyolitic flows, breccias, tuffs and associated volcaniclastic sediments. A potential genetic connection among the units is suggested by distinct regional trends in geochemical and isotopic signatures. The magmatic affinity of each unit ranges from tholeiitic to calcalkaline, with the rocks becoming increasingly calc-alkaline to the east. Incompatible trace element patterns in each unit display enrichment of LIL elements relative to HFS elements, characteristic of subduction related volcanism, and there is a systematic increase in LILE/HFSE ratios from west to east. Each unit is characterized by two suites of REE patterns, one flat (La/Yb=1.2-1.9) and one with enrichment of the LREE (La/Yb=3.0-7.0). There is an overall increase in LREE enrichment from the Bonanza Group on the west to the Harrison Lake Formation on the east. Nd and Sr isotopic signatures demonstrate the juvenile, mantle-derived character of the arc magmas, and there is a disinct shift to lower ε_{Nd} and higher $^{87}Sr/^{86}Sr$ values from the Bonanza Group to the Harrison Lake Formation that may represent magma ascent through different crustal sections. Biostratigraphic and radiometric age constraints indicate volcanism began in Sinemurian time in the Bonanza Group, and becomes increasingly younger to the east, initiated in Toarcian time in the Harrison Lake Formation. Volcanism in all units apparently ceased in Bajocian to Bathonian time.

Using stratigraphic, geochemical, isotopic, and age considerations, we will suggest that Lower to Middle Jurassic strata of Wrangellia and Harrison terranes may represent parts of a contiguous arc sequence built on different Triassic basements. If they are part of the same arc, magmatism began in the Early Jurassic on Wrangellia and spread eastward during Sinemurian to Bajocian time. The formation of a contiguous Bonanza-Harrison arc would necessarily require the juxtaposition of Triassic rocks of the Wrangellia and Harrison terranes prior to Early Jurassic time.

THE KLUANE METAMORPHIC ASSEMBLAGE, SW YUKON - FIRST STEPS TOWARDS DEVELOPING A TECTONIC MODEL.

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The Kluane Metamorphic Assemblage is a schist assemblage of unknown tectonic significance within the accreted portion of the northern Cordillera. It is a homogeneous, locally garnet-staurolite-bearing mica-quartz schist. It forms a large, 150 km long and up to 40 km wide belt in SW Yukon. It is bounded to the W by the Denali fault system, and to the north by granodiorite of the Eocene Ruby Range batholith, which intruded the schist. The eastern contact with the biotite schist of the Aishihik Assemblage, part of the Nisling terrane, is believed to be a fabric-parallel fault overprinted by metamorphism. The contact between the Kluane Metamorphic Assemblage and weakly metamorphosed flysch of the Dezadeash Formation to the SW is not exposed. The latter is in faulted contact with a chlorite schist of unknown affinity.

Fabric orientation in the Kluane Metamorphic Assemblage is constant over large areas. Foliation dips moderately NNE to SE. Crenulation cleavage is common. Extensional lineation of mica plunges gently E to ESE. Local asymmetric open folds display NW-SE striking, moderately plunging fold axes and steep NE dipping axial planes.

Gt-bt-pl-ms-thermobarometry of the biotite-rich schist record average pressures of 3.5 kbar, and temperatures ranging from 520 to 580°C (lower amphibolite grade). Garnet compositions (almandine-spessartine) suggest a sedimentary origin. Lenses of olivine-serpentine schist near the northern contact of the Kluane Metamorphic Assemblage may represent slivers of oceanic crust incorporated to an accretionary wedge. Ongoing Sm/Nd isotope studies will provide data to distinguish micaschist of the Kluane Metamorphic Assemblage from that of the Aishihik Assemblage and the Dezadeash Formation, and information on the provenance of the sedimentary protolith.

WESTERLY-DERIVED UPPER TRIASSIC CLASTIC SEDIMENTARY ROCKS IN SE YUKON: EVIDENCE FOR EARLY MESOZOIC TERRANE INTERACTIONS ALONG THE WESTERN MARGIN OF ANCESTRAL NORTH AMERICA

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A sequence of siltstone, sandstone, and limestone of Late Triassic age occurs sporadically along the western edge of Ancestral North America (ANA) in the northern Canadian Cordillera. These strata are regionally observed or inferred to rest unconformably on older strata of the miogeocline. The Triassic rocks commonly contain abundant detrital mica and locally appear to coarsen and possibly thicken to the west. In SE Yukon the sediments are intercalated with basaltic flows of uncertain tectonic affinity, and at several localities polymictic pebble to boulder conglomerate makes up a significant proportion of the sequence. Clasts in the conglomerates in this area comprise: 1) massive greenstone, gabbro, anorthosite and serpentinite; 2) metamorphic rocks including quartzite, quartz-mica schist and amphibolite; and 3) massive dacite and andesite. Both metamorphic clasts and massive dacite clasts give mid-Permian to earliest Triassic K-Ar mineral ages. None of the clasts in the conglomerate have possible sources to the east, suggesting that the Triassic sediments were derived at least in part from a composite terrane to the west which included an ophiolitic assemblage, a metamorphic assemblage, and a Late Paleozoic volcanic arc. Yukon-Tanana and Slide Mountain terranes, which are now in fault contact with the Triassic clastic strata on the west, represent possible sources of the metamorphic and ophiolitic clasts, respectively. However clasts of mid-Paleozoic metaplutonic rock and radiolarian chert, which are abundant and widespread in the Yukon-Tanana and Slide Mountain terranes, are not represented in the conglomerates, which may preclude a direct link between these terranes and the conglomerates. The Triassic sedimentary sequence is cross-cut by dykes and sills of intermediate composition that give a preliminary U-Pb age of 185 Ma, and may record a brief period of E-dipping subduction under the western edge of ANA in early Mesozoic time. The Late Triassic sequence and associated igneous rocks record some of the earliest stages of accretion in the northern Cordillera.

GEOLOGY AND MINERAL OCCURRENCES OF SEATTLE CREEK MAP AREA (115P/16), WESTERN SELWYN BASIN, YUKON

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New mapping in Seattle Creek map area in the northeastern corner of McQuesten map area completes an east-west transect of regional geological coverage from Clear Creek to Keno Hill. Seattle Creek map area is underlain by clastic metasedimentary rocks of the Late Proterozoic to Cambrian Hyland Group and structurally underlying Keno Hill quartzite (Mississippian). Volumetrically minor marble and deformed intermediate to mafic dykes of unknown age occur throughout the Hyland Group, deformed mafic rocks of possible mid-Triassic age intrude Keno Hill quartzite, and undeformed Cretaceous felsic stocks intrude Hyland Group rocks in the south-central part of the map area.

Hyland Group rocks in northern third of the area lie on the southwest-overturned limb of the Lost Horses syncline, comprising relatively weakly strained argillite, metasandstone, metaconglomerate, and marble of the Yusezyu Formation and maroon and green argillite, marble, and metasandstone of the Narchilla Formation. In contrast, highly strained gritty phyllitic psammite and phyllite of the Yusezyu Formation in the southern half of the map area is part of a broad belt here termed the Tombstone Strain Zone. In this area the gently northerly dipping northern (upper) boundary of the Tombstone Strain Zone is a narrow strain transition which coincides with a trend of aeromagnetic highs. The Tombstone Strain Zone is the exposed deeper part of the hanging wall of the Tombstone Thrust, and includes the footwall and much of the hanging wall of the older structurally overlying Robert Service Thrust.

A variety of types of mineral occurrences is found in the area including Keno Hill-type vein-faults (SEATTLE, JAYBEE) and skarns, veins, breccias and alteration zones spatially associated with the felsic stocks. Notable new results include the recognition of gold mineralization on the OLIVER occurrence in southeastern Sprague Creek map area, the discovery of an area of gold-bearing quartz-arsenopyrite veins between Highet and Bennett creeks in the southeastern part of Seattle Creek map area, documentation of gold- and arsenic-mineralized quartz veins in a satellite of the Scheelite Dome stock, and the identification of an area of hornfels and tourmaline alteration along the north boundary of the map area associated with a previously undocumented intrusion in southern Larsen Creek map area.

LOW-TEMPERATURE PRISM <c> FABRICS FROM QUARTZ MYLONITES, LITTLE SALMON LAKE, YUKON TERRITORY

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Quartz *c*-axis fabric analyses at Little Salmon Lake, Yukon Territory, indicate that unusual slip mechanisms were active within Teslin suture zone tectonites. Some mylonites containing strike-slip lineations show *c*-axis maxima parallel to the extension direction (X) which requires prism <c> slip. Because prism <c> fabrics are typically associated with high-temperature deformation, it is unusual to find them in these greenschist facies rocks. In contrast, tectonites containing dip-slip lineations display fabrics formed by <a> slip along basal, rhomb and/or prism crystallographic surfaces. In addition to single-girdle and Type I double-girdle patterns, some dip-slip fabrics are characterized by a single *c*-axis maxima parallel to the Y direction, indicative of prism <a> slip.

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Structural analysis indicates that NE-SW dip-slip fabrics formed first and were partially overprinted by nearly orthogonal top-to-the-NW strike-slip shear. We infer that transposition of prism <a> fabrics is the mechanism responsible for the low-temperature prism <c> orientations. X-ray goniometry of *a*-axis distributions within prism <c> tectonites reveals point maxima surrounding the Y direction and further support superposition of pre-existing fabrics.

Quartz *c*-axis analyses at Little Salmon Lake show that prism <c> slip can be activated at relatively low temperatures if suitable pre-existing crystallographic orientations are transposed. Conversely, the dominant role of <a> slip during prograde metamorphism is a possible reason for the scarcity of prism <c> fabrics in general. Independent of superimposed orthogonal shearing, orientations conducive to prism <c> slip will not evolve from <a> slip fabrics.

LEWIS THRUST PLATE THERMAL AND GEOLOGICAL HISTORY FROM FISSION-TRACK DATA

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Analysis of a dominant group of apatite fission track (AFT) data from Lewis thrust sheet in southeastern British Columbia and southwestern Alberta indicate the entire thrust sheet was cooled rapidly in the Maastrichtian. Very low Maastrichtian to Early Oligocene geothermal gradients are indicated when AFT cooling histories are combined with stratigraphic relationships. The rapid cooling occurred during displacement on Lewis thrust fault. This regional cooling involved a profound depression of the geothermal gradient when compared to geothermal gradients recorded both at peak predeformational temperatures, as constrained by organic maturity and zircon FT data, and at present, as indicated by temperature measurements. A subordinate group of AFT data indicates that some parts of the progressively cooling thrust sheet were reheated in the Tertiary. The character and pattern of Late Cretaceous to present geothermal fields is similar, suggesting that topographically driven hydrodynamic advective heat transfer controlled geothermal gradient variations that are as important as erosion to the cooling history.

Use of Marsh Foraminifera to Recognize Coseismic Sealevel Changes on Vancouver Island, British Columbia.

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Coastal British Columbia has a high potential for mega-thrust earthquakes, but detail on the periodicity and magnitude of prehistoric earthquakes is not well known. Analysis of marsh foraminifera from the region may provide invaluable information about rapid sea level changes associated with such seismic events. Foraminifera inhabit distinct zones within salt marshes. This attribute has proven invaluable in the recognition of rapid sea level changes in coastal area. Although research is in the preliminary stages, analysis of marsh foraminiferal faunas in cores collected along the Vancouver Island coast has permitted our research group to determine the chronology and extent of several large, late Holocene earthquakes in coastal British Columbia.

Future research will emphasize Holocene sea-level changes along the populated south-coast. This information obviously is important in assessing the likelihood and possible effects of future large earthquakes in this region. This goal will be achieved by documenting sudden sea-level change in tidal marshes and coastal bogs through: (1) lithostratigraphic and sedimentological description of cores and natural exposures; (2) diatom, pollen, and foraminiferal analysis of fossil and modern material; and (3) radiocarbon dating. A spin-off benefit will be a detailed documentation of patterns of late Holocene sea-level change on the BC. coast.

ROCK TYPES, STRUCTURE AND METAMORPHISM IN THE SLIDE MOUNTAIN TERRANE AND FINLAYSON LAKE FAULT ZONE, CAMPBELL RANGE, SE YUKON.

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The Finlayson Lake fault zone forms the boundary between autochthonous North American rocks and the innermost accreted Slide Mountain terrane (SMT) and Yukon-Tanana terrane in southeastern Yukon. Geological mapping at 1:50 000 scale in a well exposed area of the Campbell Range, southeastern Yukon, was undertaken to examine the kinematics of the Finlayson Lake fault zone and rock types of the SMT. Field data suggest that the Finlayson Lake fault zone is composed of northwesterly trending diverging thrust faults and subparallel, steep, strike-slip(?) faults. These structures are consistent with the interpretation of the Finlayson Lake fault zone as a transpressive fault zone. More constraints on the relative timing of faulting and the kinematics of the steep faults are required to test this hypothesis.

Five units were identified: (1) chloritic schist and phyllite, (2) laminated metachert and carbonaceous black slate, (3) tan weathering metachert and maroon, siliceous and argillaceous metasiltstone, (4) greenstone and associated breccia, gabbro, metagreywacke, metachert and maroon metasiltstone and (5) serpentinite. The latter is common along faults. Unit 2 is structurally interleaved with serpentinite, hornblende-feldspar porphyry, quartz-eye muscovite-chlorite phyllite or schist, chloritic schist and minor grey, calcareous metacarbonate. Metamorphic grade increases from prehnite-pumpellyite facies in the east to greenschist (epidote-actinolite) facies in the west. Preliminary P-T estimates for greenschist metamorphism, based on mineral assemblages, are 350-400 °C and 4-5 kb.

Lithologically, units 4 and 5 are similar to upper divisions of the SMT in British Columbia whereas unit 2 is similar to the lowest division of the Sylvester Allochthon in the SMT. Maroon metasiltstone in unit 3 is indistinguishable lithologically from metasiltstone in the overlying greenstone unit suggesting that the eastern thrust fault juxtaposes parts of the same depositional sequence, i.e. the SMT. Unit 1 is tentatively correlated with the Yukon-Tanana terrane.

Greenstone (unit 4) is thrust towards the southwest over unit 1 in the western part of the map area along a northwest-striking, gently northeast-dipping thrust fault. In the east, greenstone is thrust towards the northeast over unit 3 along a northwest-striking, moderately southwest-dipping thrust fault. Unit 2 is inferred to be bounded to the east and west by northwest-striking, steep(?) faults and to the south, by a east-striking, steeply dipping, normal (north-side down) fault. The northern boundary of unit 2 is unconstrained. Outcrop data and topographic patterns suggest that the eastern thrust fault is truncated by a northwest-striking, steeply dipping fault. The northwest-striking faults are poorly exposed and their kinematics have yet to be determined. However, if they are steep faults, they are likely dextral strike-slip faults.

PALEOSEISMIC STUDIES OF THE BRIDGE RIVER AREA, SOUTHWESTERN BRITISH COLUMBIA

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A paleoseismic evaluation of the Bridge River area was conducted to determine if specific faults have been the source of historic earthquakes, and should be considered as potential sources of future earthquakes. Results of the work will be used to refine assessments of seismic design parameters for B.C. Hydro facilities.

Activities involved in this study include, a literature search, compilation of Cenozoic faults, satellite image and air photo interpretation, review of seismicity, site investigations and trenching. The Hell Creek Fault, which is near one of Hydro's dams, was selected for detailed study and a trench site. The structure has been documented in the literature as having a tectonic origin by some and gravitational origin by others. The fault is interpreted as having an early (<47 Ma) tectonic origin with subsequent Holocene displacement. Certain structures that deform pond sediments at the base of a scarp on the fault trace are suggestive of lateral displacement, implying mid- to late- Holocene tectonic activity. The final results of the study are currently under preparation.

THE ISAAC LAKE SYNCLINORIUM: THE MISSING LINK IN STRUCTURAL AND STRATIGRAPHIC EVOLUTION OF THE CARIBOO MOUNTAINS, BRITISH COLUMBIA

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The Isaac Lake synclinorium is a structural depression in the western Cariboo Mountains, British Columbia, that exposes much of the Neoproterozoic Windermere Supergroup. The synclinorium is bound on the west by the Isaac Lake fault zone which is believed to be a dextral oblique strike slip fault of unknown age. The eastern boundary is also structural but changes along strike from a dextral oblique thrust fault to an unfaulted west-verging fold of probable pre- to Middle Jurassic age.

A mapping project has been initiated to better understand both the stratigraphic and structural aspects of the Isaac Lake synclinorium. Major objectives include:

1) Mapping and understanding structural boundaries and linking these to regional deformation scenarios and chronology. In particular how does the deformation in this region relate to the high grade metamorphism and deformation in the Penfold Creek area immediately to the west of the Isaac Lake Fault zone? Is the strike-slip deformation observed on the Matthew Fault coeval with the movement on the Isaac Lake Fault zone? Is it possible to independently constrain the age of formation of the Isaac Lake synclinorium?

2) Understanding internal stratigraphy of the Windermere Supergroup including the Precambrian-Cambrian boundary, the down-dip expression of the Cunningham Formation, and the stratigraphy of the Yankee Belle Formation.

WHERE DID ALL THAT MUD COME FROM? PROVENANCE EVOLUTION OF THE CORDILLERAN MIOGEOCLINE FROM NEODYMIUM ISOTOPIC STUDIES

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We report on the neodymium (Nd) isotopic composition of clastic sedimentary rocks in the Cordilleran miogeocline that range in age from ~650 Ma (Windermere Supergroup) to 80 Ma (Belly River Group). Isotopes of samarium (Sm) and neodymium (Nd) are a parent-daughter system that is relatively unfractionated by most crustal processes. The Nd isotopic composition of the crust and mantle of western Canada, and North America in general, is relatively well-known and this allows the application of isotopic measurements Sm and Nd in sedimentary rocks as a means of tracking the evolution of provenance signatures. The goals of this study were 1) to develop a North American miogeoclinal reference for Nd isotopes and to provide a baseline for continental input to the terranes of the Canadian Cordillera, 2) constrain the importance of proximal and distal North American basement sources for these sediments and 3) constrain the timing of juvenile terrane accretion at the Cordilleran margin.

εNd values calculated for the time of sedimentation for Neoproterozoic (Windermere Supergroup) to Upper Ordovician (Mount Wilson Quartzite) rocks of the miogeocline range from -20.7 to -14.3 and are easily explained by derivation of sediment from proximal sources within the crystalline basement of Alberta. A positive shift of 6 εNd units occurs in the Upper Devonian Sassenach Formation (-9.5) and persists until foreland basin sedimentation in the Upper Jurassic. The Devonian to Triassic (Whitehorse Formation) εNd values vary only slightly from -9.5 to -6.7 and requires input from isotopically juvenile sources. Three scenarios are possible: 1) sediment input from juvenile fringing island arcs and back-arc basins such as Quesnellia and Slide Mountain Terrane, 2) sediment derivation from the Appalachian orogen of eastern North America and 3) sediment derivation from Ellesmerian sources in the Canadian Arctic. Option 1 is considered unlikely because typical arc magmas, such as basaltic andesite, have much lower Nd concentrations than continental crust (10 ppm vs. 35 ppm, respectively) and mass balance calculations suggest that more than 50% of the material in the samples we analyzed would have to be volcanic in origin. This is difficult to reconcile with quartzose composition of many of the units (Sassenach, Rocky Mountain Group etc.). Option 2 is tantalizing because of the isotopic similarity of the Devonian-Triassic of the Cordillera with sedimentary strata of the Appalachian foreland (e.g. Ouachita trough) but is considered unlikely because of the persistence of the Trans-Continental Arch, a paleogeographic feature that would have blocked drainage westward from the Appalachians. Option 3 is considered the most likely but must await testing as isotopic data from the Canadian Arctic is lacking.

Foreland basin sediments of Upper Jurassic (Fernie Formation) to Cretaceous age (Belly River; Chungo Member) show marked heterogeneity but appear to diverge in terms of εNd values. Some samples tend towards more evolved signatures (negative ε values) whereas others appear to tend towards more primitive (positive ε) signatures. This is interpreted to reflect the relative proportions of detritus derived from erosion of pre-Devonian strata in the thrust belt, characterized by negative Nd signatures, and volcanic detritus, likely derived from the southern Coast Belt of southwest Canada or possibly terranes west of the Omineca Belt, characterized by relatively juvenile (positive) Nd signatures.

SULFUR ISOTOPIC COMPOSITION OF WINDERMERE PYRITES: SIGNIFICANCE FOR STRATIGRAPHIC CORRELATIONS, SEAWATER CHEMISTRY AND THE EVOLUTION OF METAZOANS:

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The Neoproterozoic was a fundamental time in Earth history during which the intertwining of tectonic, climactic and geochemical processes culminated in the first appearance of metazoan life forms. Available $\delta^{13}C$ data from marine carbonates indicate dramatic variations in the record of organic carbon burial which affects the oxygen reservoir, a key control on evolution of metazoan respiration. A missing element from existing isotopic studies has been data from sedimentary rocks of deep water aspect, as well as a clear understanding of the role of sulfur in these changes.

The Neoproterozoic record in the southern Canadian Cordillera (SCC) is characterized by sedimentary rocks of the Windermere Supergroup that formed on the slope of a passive continental margin. Pyrite is a common constituent in many of these rocks and thus provides an opportunity to examine the burial history of sulfur. Isotopic data from the analysis of authigenic pyrite in the Kaza Group and Isaac Formation (Cariboo Mountains) indicate a large component of ^{32}S-enrichment with values up to δ=-31 permil. The isotopic compositions of the pyrites span a broad range of ca. 50 permil in each of two units examined, indicative of sulfide formation by bacterial sulfate reduction, perhaps in a euxinic marine basin, and influenced by diffusion-controlled sulfate availability. The most ^{34}S-enriched values of the pyrites (+18 and +32) are inferred to approximate the isotopic composition of sea water preserved as a consequence of the rate of sulfate reduction exceeding the rate of sulfate diffusion (i.e. effectively a closed system). Measured sections through the Middle and Upper Miette groups (western Rockies) and a section in the Horsethief Creek Group (Purcell Mountains) show very similar isotopic patterns as those observed in the Cariboos. This is encouraging from the perspective of confirming lithostratigraphic correlations but has potentially greater application in understanding the evolution of seawater sulfate during this time interval.

The degree of ^{32}S enrichment observed in the Windermere pyrites is unknown from Neoproterozoic rocks but is a necessity to balance the isotopic composition of evaporitic sulfur. A shift to ^{34}S-enriched compositions (+32) of late Neoproterozoic sea water is known from evaporites (e.g. Claypool et al.) but the ^{34}S-depleted sulfide reservoir has never been found, leading to an enigma in the mass balance of sulfur. The SCC is suggested as an analogue of the process of ^{32}S burial that may have occurred on a more widespread, but rarely preserved, scale in the Neoproterozoic and eventually led to enrichment of sea water sulfate in ^{34}S. When coupled with the burial of iron as pyrite, these processes may have impacted on the oceanic oxygen budget. This mechanism may have provided the final push beyond the threshold of free oxygen required for the development of aerobic respiration and the appearance of metazoans.

STRATIGRAPHY OF PARAGNEISSES IN VALHALLA COMPLEX, SOUTHERN OMINECA BELT, BRITISH COLUMBIA

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The Valhalla complex is an exhumed metamorphic core complex situated within the southern Omineca Belt of the Canadian Cordillera. The complex is bounded by two normal faults: the east dipping Slocan Lake fault and the east rooting Valkyr shear zone which arches over the complex and merges with the Slocan Lake fault.

This study focuses on sheets of upper amphibolite-facies paragneiss which occur at three structural levels, including two windows exposed in the footwall of the Gwillim Creek shear zones. Recent mapping of stratigraphy has identified a heterogeneous package of metasedimentary rocks. Transposed stratigraphy is preserved despite the intrusion of ubiquitous Paleocene-Eocene Ladybird leucogranites and pegmatites which may comprise as much as 50 -75 % of the unit. Mapping was facilitated by the presence of distinct marble, quartzite-pebble metaconglomerate and ultramafic marker units. The sequence includes a varied assemblage of semipelitic and psammitic schist, marble, calc-silicate gneiss, quartzite, quartzite-pebble metaconglomerate, pelitic schist, amphibolite gneiss and ultramafic boudins. These rocks are characterized by a notable lack of both amphibolite and thick layers of pelitic schist in the structural higher areas.

Lithologic similarity with rocks in both the Thor-Odin - Pinnacles area and the Goat Ranges allows a tentative correlation with the Badshot Formation, Lardeau Group and Milford Group. In this interpretation, the metasedimentary rocks in Valhalla comprise an inverted stratigraphy of Cambrian Hamill Group to Carboniferous Milford Group. This package of rocks lies in the hanging wall of the Gwillim Creek shear zones and has implications for the subsurface correlation of the Gwillim Creek shear zones in regional cross-section and Lithoprobe seismic reflection data.

Geometry of metamorphic isograds at the northern margin of Shuswap complex, northern Monashee Mountains, B.C.

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Small displacements on Tertiary normal faults in conjunction with post-metamorphic warping of Mesozoic structures in the northern Monashee Mountains, related to a crustal-scale ramp on the south flank of the Malton basement complex, provide 3-D control on metamorphic boundaries in a critical portion of the north margin of the Shuswap composite core complex. This has enabled us to construct a 3-D model of isogradic surfaces and to refine the interpretation of a broad zone where kyanite and sillimanite coexist through a depth range of more than 2 km.

STRATIGRAPHY, STRUCTURE AND METAMORPHISM IN THE DORSEY RANGE, SOUTHERN YUKON TERRITORY AND NORTHERN BRITISH COLUMBIA: THE CASE FOR A SEPARATE AND DISTINCT DORSEY TERRANE

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The Dorsey terrane is an enigmatic terrane in the northern Canadian Cordillera. Investigations in the Dorsey Range, aimed at establishing the defining characteristics of this terrane and resolving the nature of the faults that surround it, have produced several important preliminary conclusions.

In the Dorsey Range, the informally named Dorsey assemblage and the mid-Permian Ram Stock characterize the Dorsey terrane. The Dorsey assemblage can be divided into three units. The lower unit consists of a siliciclastic-dominated, continental margin-type sequence that varies up-section to a more basinal or oceanic-type sequence of chert, phyllite, epiclastic, carbonate (in part Pennslyvanian) and volcanic rocks, in the middle and upper units. The three units are interpreted to be in transposed stratigraphic contact. Metamorphic grade varies from greenschist to amphibolite facies in the lower unit to subgreenschist in the upper unit. Deformation varies from penetrative and ductile in the lower unit to localized and more brittle in the upper part of the middle unit and in the upper unit. Both metamorphism and penetrative deformation occurred before intrusion of the cross-cutting Ram Stock. Along the northeast margin, the Dorsey assemblage and Ram Stock are separated from the North American miogeocline by a steeply southwest-dipping package of rocks interpreted to be a series of imbricate thrust slices juxtaposed during accretion of the Dorsey terrane to the North American margin. Fabrics in this "imbricate assemblage" are cut by an Early Jurassic? pluton. Along the southwest margin, the Dorsey assemblage is interpreted to be in fault contact with a distinctly different package of rocks exposed immediately to the southwest.

Preliminary assessment of the Dorsey assemblage and Ram Stock suggest that although they are similar to rocks in other terranes (e.g. Kootenay and Slide Mountain terranes) they appear to have a tectonstratigraphy and history of metamorphism and deformation that is distinct in the Canadian Cordillera.

Structural analysis in migmatites of the Thor-Odin dome, Monashee complex, British Columbia

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The complexity of structures in migmatites has been documented by several authors and related to the presence of a melt phase. Consequently, standard analysis of folds and shear zones seems to be inappropriate in migmatitic terrains. Another problem is the recognition of mechanisms of melt segregation and magma mobility from the outcrop to the crustal scale. A clue is to use the geometry and location of leucosomes within the migmatite.

Because partial melting and deformation are often synchronous, melt segregation and migration is controlled by the complex interplay of pressure gradients generated by gravity (compaction) and deformation (opening of voids and cracks in shear zones and in between boudins). In addition, structures such as cauliflowers and melt accumulation below impermeable/competent layers can be interpreted as way-up criteria, assuming that melt is migrating dominantly upward. The ability of the magma to move in mass is correlated with the Rheologic Critical Melt Percentage (RCMP = 30-50% of melt), which corresponds to a drastic decrease in rock strength related to loss of the solid framework. This transition from solid-dominated to liquid-dominated behavior is correlated with the transition metatexites-diatexites in migmatitic domains.

Based upon these concepts, preliminary analysis of partial melting processes in the Thor-Odin dome (Monashee core complex) shows that: (1) the terrain is not overturned; (2) the core of the dome is dominantly composed of diatexites whose mobility may have played an active role in the formation of the dome; and (3) partial melting and deformation were synchronous.

AN ALTERNATIVE INTERPRETATION OF STRATIGRAPHIC RELATIONSHIPS BETWEEN NEOPROTEROZOIC/LOWER CAMBRIAN ROCKS, S.E. CANADIAN CORDILLERA, AND IMPLICATIONS FOR CONTINENTAL RIFTING

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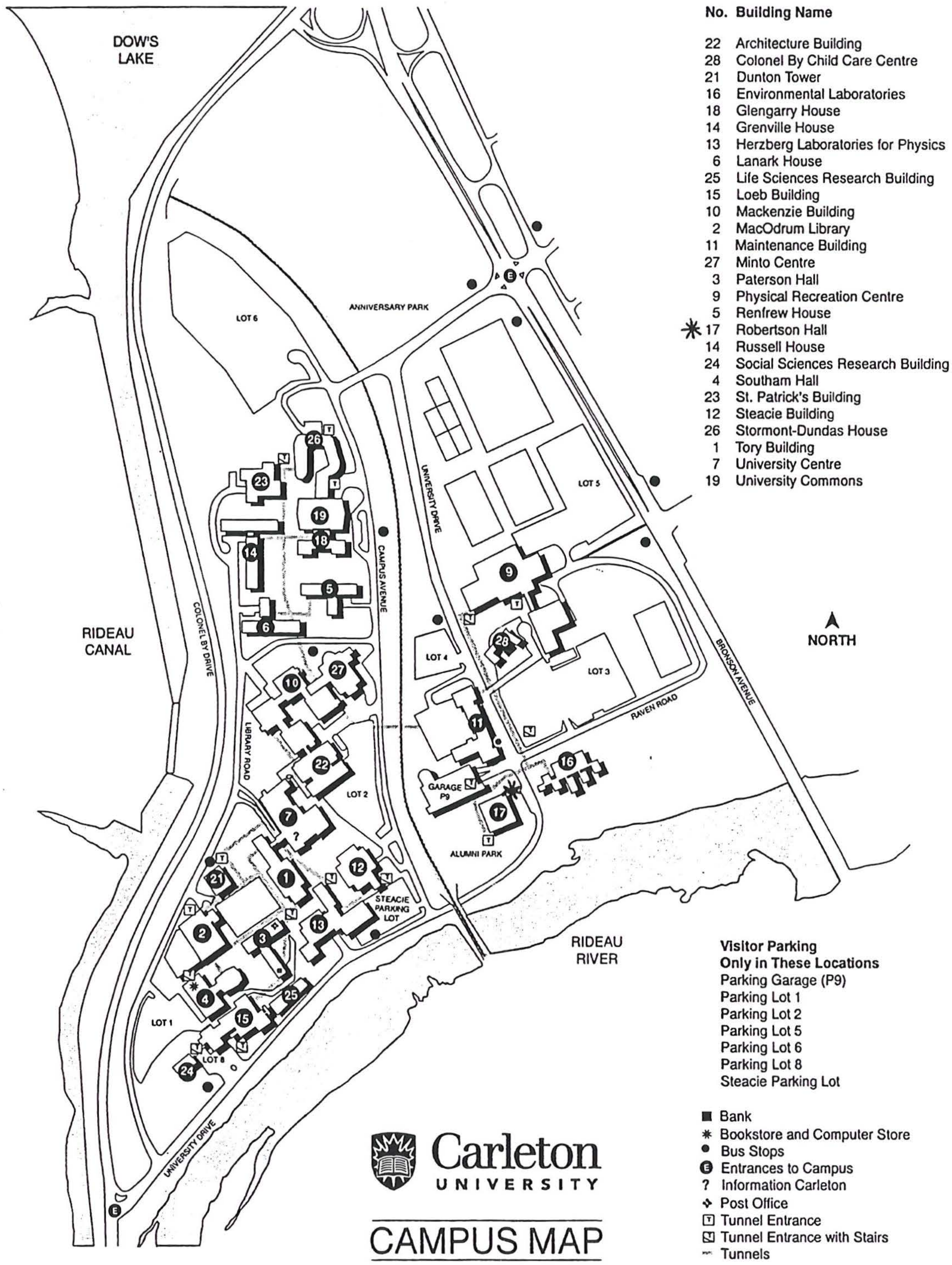
The nature and timing of continental rifting remain critical and controversial questions in Canadian Cordilleran geology. A crucial component of this debate involves uncertainty about the location in the stratigraphic record of the rift-to-drift transition for an inferred continental rifting event in the Latest Neoproterozoic/Earliest Cambrian. Many previous workers in the southern Canadian Cordillera have inferred a significant regional unconformity at the major lithological change which marks the contact between the Windermere Supergroup and overlying more mature quartzose sedimentary rocks (Hamill and Gog Groups, and equivalent rocks). However, these workers commonly have described both vertical and lateral gradations between the Windermere Supergroup and overlying rocks. Furthermore, much of the unfossiliferous lowermost Hamill/Gog Groups, and equivalent rocks, was included in the Lower Cambrian solely on the basis of lithological similarity to overlying strata which contain Lower Cambrian fauna.

In the west-central Purcell anticlinorium and in the adjacent Kootenay Arc, east of Duncan Lake, B. C., the uppermost, shallow marine unit of the Hamill Group rests unconformably on several underlying fluvial and/or shallow marine units which are sedimentologically distinct from it, or it rests directly on the Windermere Supergroup. Stratigraphic relationships, provenance of sediment and the local presence of mafic volcanic rocks in the lower part of the Hamill Group imply that formation of one or more half-grabens post-dated the deposition of most of the upper part of the Windermere Supergroup, accompanied the deposition of the lower part of the Hamill Group and preceded the deposition of the upper part of the Hamill Group.

These stratigraphic relationships in the central Purcell Mountains, compiled with stratigraphic, sedimentological and fossil data from equivalent strata in the southern and northern Purcell and Selkirk Mountains and Main Ranges of the Rocky Mountains, imply that a regionally persistant and significant unconformity occurs within, rather than at the base of, the Hamill Group and equivalent strata. Strata that lie above this unconformity can be correlated regionally and are clearly Lower Cambrian. Quartzose strata that lie below this unconformity are not regionally continuous and could be Neoproterozoic. They rest with little significant break at nearly the same stratigraphic level on the upper part of the Windermere Supergroup. In localities where a significant thickness of the Windermere succession is missing, the lower part of the Hamill/Gog Groups is also missing beneath the unconformity.

Interpretations of these data further suggest that the uppermost Windermere Supergroup and lower Hamill/Gog Groups were preserved on the down-dropped sides of normal faults, which stepped up progressively to the south and east. Shallow marine strata subsequently onlapped across the faulted margin. *If* continental rifting did occur in Earliest Paleozoic time, as several recent models suggest, then this unconformity is proposed as the most likely expression of this rift-to-drift transition in the stratigraphic record. This model is presented as a working hypothesis, which should be tested more rigourously in the future with appropriate sedimentological, lithostratigraphic, biostratigraphic and chemostratigraphic methods.



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Lunch possibilities:

Cafeteria on third level of University Commons Building (#19) - purchase all-you-can-eat meal ticket at Residence Service Desk in main foyer ($6 plus taxes), 11:30 - 1:15

University Centre Building (#7) - Mr. Sub, second level - Domino Pizza in Rooster's, fourth level, opens at noon

Physical Recreation Centre (#9) - Fitstop (sandwiches, hot dogs, etc.)

Snack huts on canal (warning: long lines)